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Feasibility study of linear Fresnel solar thermal power plant in Algeria

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Outline

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2 Generality

3 Optimization Calculation

4 Sizing Analysis

5 Conclusion and related aspects

PROBLEMATIC AND OBJECTIVE

- The higt energy demand
- The environmental protection
- Algeria with an important solar potential , specially in Sahara
- Algeria has began to explore this source of energy

The idea is to build a concentrating solar power plants (CSP).

Our main objective in this work is a theorical modeling, and sizing analysis of linear Fresnel solar power plant in different Algerian sites

Concentrating solar power plants (CSP)

Parabolic-trought

Fresnel concentrator

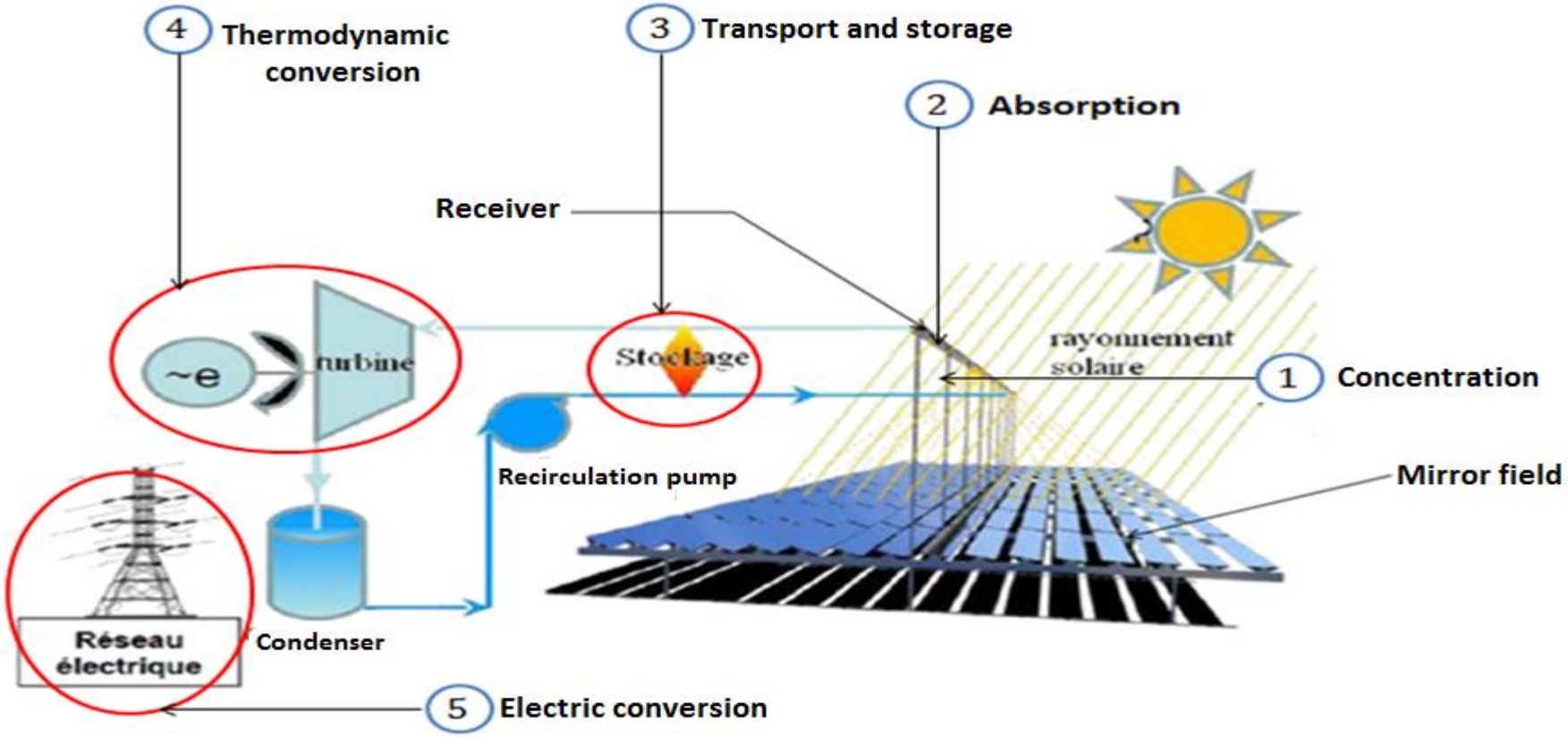
Linear concentration

Dish-Stirling

Solar tower

Point concentration

GENERALITY



- The concentration of the radiation on the receiver input,
- The absorption of the concentrated solar radiation on the receiver, and to transform its energy into heat.
- Transport, and storage of this heat.
- The conversion of heat into mechanical work through a thermodynamic cycle, then the work is converted to electricity through an alternator.

SIZING CALCULATION

- The generator output power is equal to: Pg =5 MW electric
- In order to supply a small city whose daily consumption is 5KW per family of electricity, each family is composed of 5 persons.

Polyclinic	=0.2 MW	5 MWe
Factory	= 1 MW	
Administration	= 0.5MW	
Inhabitants	= 3 MW	
Others	= 0.3 MW	

- With SM is the solar multiple =1.6, which corresponds to 6 hours of storage.
- The selected locations are:
  - West → BeniAbbes
  - Center → HassiR'Mel
  - East → ElOued
  - South → Tamanrasset

Why have we chosen theis sites ?

- Long periods of direct normal irradiation measurments
- Normal Direct Irradiation higher or equal to 2000 kWh/m²/year
- Site topography: flat, slop less than 5%
- Land price
- Nature of the land
- Weather :hot and dry
- Proximity to the electrical network
- Proximity to the gas network (for backup)

- Proximity to the infrastructures
- The high price of conventional electricity (kWh)
- The availability of water sources
- Dust and industrial areas
- The absence a week frequency of sand wind
- Location not very windy (<30 days per year)
- Far distance from public residences

SITE METEOROLOGICAL

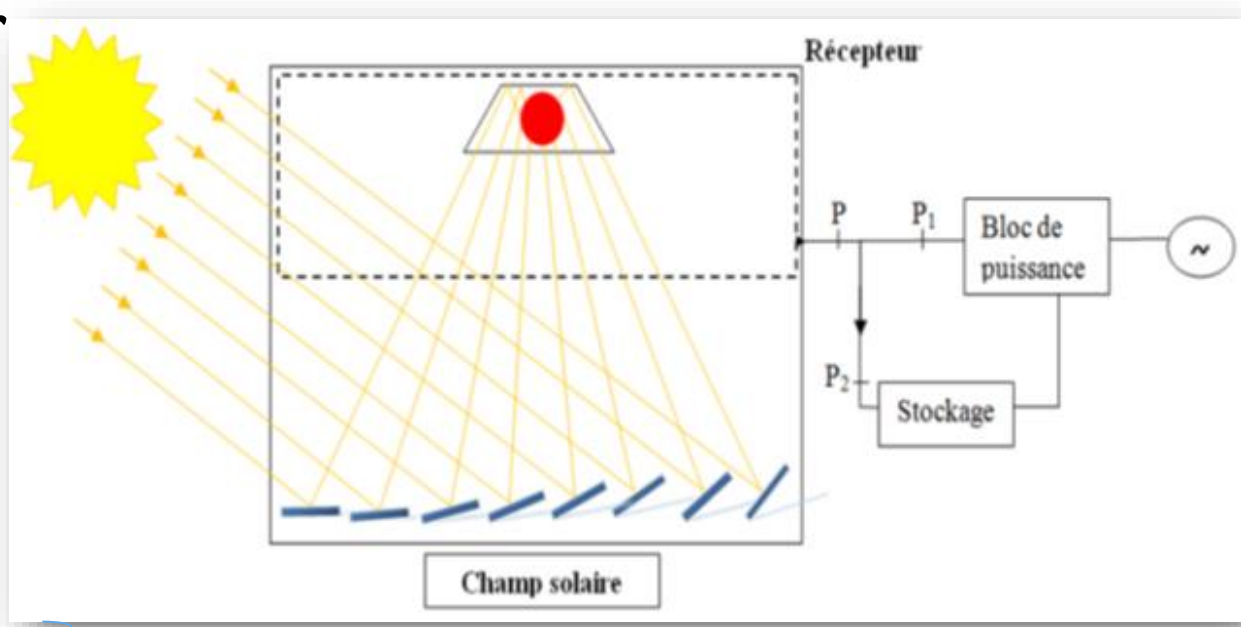
Sites selected	B A	HassiR'mel	El Oued	Tam
DNI_{annual} (KWh/m2.year)	2236	2035.5	2149.5	2759.4
T_{ambmoy}(°C)	22	22.4	21.4	22.7
Insolation duration (hours/year)	3200	3200	3200	3600
$DNI_{moy}(W/m^2)$	698.7	636	671.7	788.4

CALCULATION OF PLANT CHARACTERISTICS

DNIavr calculation (Direct Normal irradiance)

$$\text{DNI avg} = \frac{\text{DNAannual}}{\text{Insolation Duration}} = \frac{2236}{3200} = 0.698 KW/m^2 * 10^3 = 698.7 W/m^2 \text{ for Béni – Abbes}$$

Calculation of power



$$P_1 = \frac{P_g}{\eta_{bloc}} = \frac{5}{0.35} = \mathbf{14.28\ MW_{thermique}}$$

$$P = P_1 + P_2 = SM * P_1$$

$$P = SM * P1 = \mathbf{22.84 MW_{thermique}}$$

$$\text{Donc : } P_2 = P - P_1 = 22.84 - 14.28 = \mathbf{8.56 MW_{thermique}}$$

Calculation of field surface for each location

receiver efficiency =85 %

Optical efficiency = 45%

So, global efficiency is obtained:

η_{global}=0.85*0.45=0.38=**38%**

$$\eta_{global} = \frac{p}{A * DNI} \Rightarrow A = \frac{P}{n_g * DNI} = \frac{22.84 * 10^3}{0.38 * 0.698} = 86000 m^2$$

Calculation of block number and surface of each block

The size of plant solar field is S =21571m²

This plant contains 2 blocks, each block has a power of 0.7 MW electric

$$\frac{A}{S} = \frac{86000}{21571} = 3.98 * 2 = 8 \text{ blocks}$$

"A" block surface : $\frac{86000}{8} m^2$ for Beni - Abbes

PLANT CHARACTERISTICS IN 4 SITES

Selected locations	Beni-Abbes	HassiR'mel	El Oued	Tamanrasset
$DNI_{moy}(W/m^2)$	698.7	636	671.7	788.4
Solar field surface	86000	94000	89000	76000
Block number	8	8	8	7
Block surface (m^2)	10750	10804	10853	10857
Unit number of a block	21	21	21	21
Actual absorber surface (m^2)	564.48	564.48	564.48	564.22
Total surface of absorbers (m^2)	4515.8	4911	4628.7	3949.5
Lost power (W)	$2.93*10^6$	$3.19*10^6$	$3*10^6$	$3.5*10^6$

Conclusion

- According to this study, we were able to notice the importance of a good choice of the power plant site, as each site is characterized by its direct radiation, ambient temperature, insolation duration, wind speed, latitude, height above sea level, and other factors which play a key role in the power plant cost-effectiveness and productivity. This is clearly shown in the results obtained according to which the plant different parameters and characteristics vary when it is shifted in different sites.

Conclusion

- According to the results obtained for the plant different characteristics in the 4 sites, we can see that Algeria has a great opportunity to choose this kind of linear Fresnel concentrator solar power plant.

Related aspects / potential of Africa-EU research cooperation

- Help and encourage Algerian government to use Renewable Energy in energy mix.
- Adaptation of CSP power plants in the Algerian climate
- Determine the interest of solar thermal power plant to produce electricity in continus (Storage and hybridization).
- Knowledge and expertise
- Help specialists in the field to develop tender specifications for implementation of CSP power plants

Thank you for your attention